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Applicability of Abstraction and Control
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Abstract

This document extends the I-D.draft-ietf-teas-actn-poi-applicability to the use case where the DWDM optical coherent interface is equipped on the Packet device. The document analyzes several control architectures and identifies the YANG data models being defined by the IETF to support this deployment architectures and specific scenarios relevant for Service Providers. Existing IETF protocols and data models are identified for each multi-layer (packet over optical) scenario with a specific focus on the MPI (Multi-Domain Service Coordinator to Provisioning Network Controllers Interface)in the ACTN architecture.

Status of This Memo

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1. Introduction

The full automation of the multilayer/multidomain network is a topic of high importance in the industry and the service providers community. Typically, the layers composing such network are the IP/MPLS packet domain (with Segment Routing) and the Optical domain providing DWDM transmission and photonic switching. The requirements of high bandwidth availability and dynamic control of the networks are of capital importance too. The [I-D.draft-ietf-teas-actn-poi-applicability] specifies very well how to control and manage multilayer/multidomain networks using the Abstraction and Control of TE Networks (ACTN) architecture, see also Figure 1.

1.1. New coherent pluggable optics

Coherent pluggable digital coherent optics, such as ZR [OIF-400ZR-01-0] and ZR+ [Open_ZR-Plus_MSA], are enabling new multilayer network use cases where the DWDM optical transmission function is located within the packet domain equipment instead of being part of the Optical domain Figure 2. This means that an IP/MPLS capable device becomes a multi-technology IP/MPLS/Optical device, as the optical connections (OTSi service and media channels) start and end at such devices.

The coherent pluggable interface deployment in routers has already started and are expanding significantly. The way the pluggables are in general managed is not yet completely specified and defined by any standard and it is becoming an urgent matter to cover for Service Providers. A full end-to-end management solution of these pluggable digital coherent optics, leveraging on ACTN hierarchical architecture, is becoming critical to allow a wider deployment beyond simple point-to-point high-capacity link scenarios between two IP/MPLS routers.

The ACTN architecture, defined in [RFC8453] and depicted in Figure 1 , is used to control the multi-layer and multi-domain network shown in Figure 2, where each Packet PNC (P-PNC) is responsible for controlling its IP/MPLS domain, which can be either an Autonomous System (AS), [RFC1930], or an IGP area within the same operator network. Each Optical PNC (O-PNC) in the below topology is responsible for controlling its own Optical Domain.

```
                               +----------+
                               |   MDSC   |
                               +-+-++-+-+-+
                                 | |  | |
                  +--------------+ |  | +--------------+
      MPI interf. |           +----+  +-----+          |
                  |           |            |           |
             +----+----+ +----+----+  +----+----+ +----+----+
             | P-PNC 1 | | O-PNC 1 |  | O-PNC 2 | | P-PNC 2 |
             +----+----+ +----+----+  +----+----+ +----+----+
                  |           |            |           |
                  |           \            /           |
        +-------------------+  \          /  +-------------------+
   CE1 / P.N.1         P.N.2 \  |        /  / P.N.3         P.N.4 \ CE2
   o--/---o               o---\-|-------|--/---o               o---\--o
      \   :               :   / |       |  \   :               :   /
       \  : PKT Domain 1  :  /  |       |   \  : PKT Domain 2  :  /
        +-:---------------:-+   |       |    +-:---------------:-+
          :               :     |       |      :               :
          :               :     |       |      :               :
        +-:---------------:------+     +-------:---------------:--+
       /  :               :       \   /        :               :   \
      /   o...............o  O.N.  \ /    O.N. o...............o    \
      \     Optical Domain 1       / \       Optical Domain 2       /
       \                          /   \                            /
        +------------------------+     +--------------------------+
```

Figure 1: Reference multilayer/multidomain Scenario

Figure 2 shows how the Packet Node DWDM coherent Ports are connected to the ROADM ports.

```
      +------+       +------+  _________  +------+       +------+
      |P.N.1 |       | O.N. | /        /\ | O.N. |       |P.N.2 |
      |    P1| ----- |      ||        |  ||      | ----- |P1    |
    ==|    P2| ----- |      ||Optical |  ||      | ----- |P2    |==
    ==|    P3| ----- |      ||Network |  ||      | ----- |P3    |==
      |    P4| ----- |      ||        |  ||      | ----- |P4    |
      |      |       |ROADM | \________\/ |ROADM |       |      |
      +------+       +------+             +------+       +------+
   Packet+Optical              Optical              Packet+Optical
       Layer                   Layer                      Layer
```

P.N. = Packet/Optical Node (IPoDWDM router)
O.N. = Optical Switching DWDM Node (ROADM)
ROADM = Lambda/Spectrum switch
Px = DWDM (coherent pluggable) Router ports

Figure 2: Cross layer interconnection

2. Reference architecture and network scenario

As described in Figure 1 and according to the Packet Optical Integration (POI) draft [I-D.draft-ietf-teas-actn-poi-applicability] in which ACTN hierarchy is deployed [RFC8453], the PNCs are in charge of controlling a single domain (e.g. Packet or Optical) while the MDSC is responsible to coordinate the operations across the different domains having the visibility of the whole multi-domain and multi-layer network topology.

An architecture analysis has already been carried out by the MANTRA sub-group in the OOPT – (Open Optical & Packet Transport)a Telecom Infra Project (TIP) group Project Group in the MANTRA whitepaper [MANTRA-whitepaper-IPoWDM].

Two different architectural options have been identified, namely:

- Option 1: Dual SBI management of IPoDWDM routers
- Option 2: Single SBI management of IPoDWDM routers

Both the options foresee that the packet and the optical domain are kept separate from a management perspective.

2.1. Option 1 - Dual SBI management of IPoWDM routers

The figure Figure 3 describes the architecture of option 1.

```
                           +----------+
                           |   MDSC   |
                           +--+----+--+
                              |    |
     MPI interface    +-------+    +-------+
                      |                    |
                 +----+----+          +----+----+
                 |  P-PNC  |          |  O-PNC  |
                 +--+---+--+          +----+----+
                    ^   ^               ^  ^  ^
                    |   |               |  |  |
            +-------+   +---------------|--|--|------+
            |                           |  |  |      |
            |   +-----------------------+  |  +--+   |
            |   |               +----------+     |   |
            |   |               |                |   |
            |   |               v                |   |
            v   |        +--------------+        |   v
           +-----+      /                \      +-----+
          / P.N.1 \..../..O.N--------O.N..\..../ P.N.2 \
          \       /    \  Optical Domain  /    \       /
           +-----+      \                /      +-----+
                         +--------------+
```

P.N. = Packet/Optical Node (IPoWDM router)
O.N. = Optical Switching DWDM Node (ROADM)
ROADM = Lambda/Spectrum switch

Figure 3: Dual SBI management Scenario

The peculiarity of this option consists of the fact that both the packet SDN controller (P-PNC) and the optical SDN controller (O-PNC) have access to the coherent pluggable optics on the routers. The P-PNC is the only entity allowed to configure them, while the O-PNC is granted with read-only permissions to avoid database inconsistency between them. Data write access permissions are expected to be implemented on the routers to only grant configuration rights to the P-PNC.

The read-only capabilities of the O-PNC consist in the following tasks:

- Device discovery, poll or stream configuration, state and static capabilities.
- Performance monitoring, periodically poll or stream performance counters.
- Fault notification, received asynchronous alarm notifications.

The consequence of this split of roles is that the P-PNC exposes the coherent pluggables configuration APIs, while the O-PNC only the APIs needed for path computation (for OTSi services planning) and service provisioning for OLS media channel services.

2.2. Option 2 - Single SBI management of IPoWDM routers

The architecture related to option 2 is more meeting a canonical ACTN approach, i.e. any PNCs only manage resources related to his own administrative domain, like in [RFC8453] and [I-D.draft-ietf-teas-actn-poi-applicability] is described in figure Figure 4.

```
                           +----------+
                           |   MDSC   |
                           +--+----+--+
                              |    |
     MPI interface    +--------+   +-------+
                      |                    |
                 +----+----+          +----+----+
                 |  P-PNC  |          |  O-PNC  |
                 +--+---+--+          +----+----+
                    ^   ^                  ^
                    |   |                  |
            +--------+  +------------------|---------+
            |                              |         |
            |                              |         |
            |                   +----------+         |
            |                   |                    |
            |                   v                    |
            v            +--------------+            v
           +-----+      /                \      +-----+
          / P.N.1 \..../..O.N--------O.N..\..../ P.N.2 \
          \       /    \  Optical Domain  /    \       /
           +-----+      \                /      +-----+
                         +--------------+
```

P.N. = Packet/Optical Node (IPoWDM router)
O.N. = Optical Switching DWDM Node (ROADM)
ROADM = Lambda/Spectrum switch

Figure 4: Single SBI management Scenario

In option 2 the P-PNC is the only component which has access to the routers and implements all the management capabilities. In this case the P-PNC not only needs to expose to the MDSC all the needed info for the management of the multi-layer network, but also physical impairment data needed for the computation and validation of the

optical channel. In addition, also performance data need to be exported, as well as the API needed for the configuration of the pluggables.

In other words, the P-PNC is in charge of discovering the devices (both the routers and the pluggables), configuring them, monitoring the performances and managing the faults via the asynchronous notifications coming for the devices. The information collected needs to be exposed on the controller NBI and made available to the MDSCs, OSS systems or other applications. The pluggables characteristics can be exposed using [I-D.draft-ietf-ccamp-dwdm-if-param-yang] and [I-D.draft-ietf-ccamp-optical-impairment-topology-yang].

The role of the MDSC can be summarized into the following functions: discovery of the pluggables capabilities, consolidation of topology and services at all layers from L0 to L3, provisioning of multi-layer services including the OTSi service (whose path computation can be done by the MDSC itself or requested to the O-PNC), monitoring the performances and managing the faults/alarms of the services at all layers.

As the path computation for the optical layer is performed by the O-PNC, it needs to expose path computation APIs to the MDSC in order to accept the path characteristics or return the effective patameters of the computed path.

Updates to the ACTN MPI interface

A specific standard interface (i.e. ACTN MPI - MDSC-PNC interface) allows the MDSC to interact with the different O/P-PNCs. Although the MPI interface should present an abstracted topology to the MDSC (hiding technology-specific aspects of the network and hiding topology details depending on the policy chosen) in the case of DWDM coherent pluggable located in the router some information related to the physical component must be shared on MPI. The above statement is assumed as the Domain PNC (e.g. O-PNC) may not be able to get information from a node belonging to a different domain (e.g. P-PNC) or to set parameters.

To better explain the reason of this change, there are two phases before setting an optical circuit:

O-PNC routing and wavelength assignment and Optical Circuit Feasibility.

During the first phase the MDSC can ask the O-PNC to set an optical circuit between two ROADM ports (A and Z). The O-PNC having the full Optical Topology network knowledge can calculate the Optical Path, the wavelength assignment (RWA), etc. K-circuits may be calculated and sorted based on some parameters (e.g. number of hops, path length, OSNR, etc.)

Optical Circuit Feasibility

During the optical circuit feasibility, the O-PNC can calculate the estimated OSNR for the A to Z circuits and sort them from the best to the worst performance or select the most suitable one from a optical performance standpoint. To verify the circuit feasibility the O-PNC needs to know the Transceiver optical characteristics, e.g. OSNR Robustness, DC capability, supported PDL, FEC, etc. For more details refer to [I-D.draft-ietf-ccamp-dwdm-if-param-yang] and [I-D.draft-ietf-ccamp-optical-impairment-topology-yang]. The above parameters may not be directly retrieved from Packet Node by the O-PNC, (e.g. because the Packet Node supports only proprietary models or the Packet Nodes is not able to support dual writing operation or the Packet Node belongs to a different IP AS nor reachable by O-PNC), then they must be read by the P-PNC, shared to MDSC via MPI and finally to O-PNC. Other parameters like central frequency and transmit power are calculated by the O-PNC and must be provisioned to the Pluggable optics when the circuit is set-up.

Transceiver optical parameters capabilities

We can summarize here the list of parameters needed for O-PNC to compute optical circuit feasibility and spectrum allocation. The parameters are read by the P-PNC from the DWDM pluggable and shared with MDSC to give the visibility of the pluggable characteristics.

Nominal Central frequency

After having verified the Circuit Optical feasibility the O-PNC shares the channel central frequency to MDSC so that the MDSC can ask P-PNC to provision the Lambda to Router Pluggable.

FEC Coding

This parameter indicates what Forward Error Correction (FEC) code is used at Ss and Rs (R/W) (not mentioned in G.698.2), it is used by the O-PNC to calculate the optical feasibility. The FEC coding list (FEC can be many) supported by the pluggable is an input for O-PNC, one coding is selected for a specific circuit and is shared (as output) to MDSC for pluggable provisioning.

Modulation format

This parameter indicates the list of supported Modulation Formats and the provisioned Modulation Format. It is an input for O-PNC

Transmitter Output power

This parameter provisions the Transceiver Output power.

Receiver input power range

This parameter is the Min and Max input power supported by the Transceiver, i.e. Receiver Sensitivity. It is an input for O-PNC to properly calculate the optical power to set at ROADM port

Receiver input power

This parameter is the measured input power at the receiver. It is an input for O-PNC to properly check the patchcord (between transceiver and ROADM) loss comparing it with the ROADM port received power.

Operational-mode

In order to make the MPI communication more efficient and improve the abstraction, the above (and more) parameters can be summarized by the operational-mode parameter. The operational mode is described in section 2.5.2 of [I-D.draft-ietf-ccamp-optical-impairment-topology-yang].

The above optical parameters are related to the Edge Node Transceiver and are used by the Optical Network controller in order to calculate the optical feasibility and the spectrum allocation. The parameters are read by the P-PNC from the DWDM pluggable and shared with MDSC to give the visibility of the pluggable characteristics. MDSC can use the info to understand the pluggable capability and, again, share the same info to O-PNC for the impairment verification.

Pluggables provisioning

On the opposite direction O-PNC can send to MDSC the values (e.g. operational mode, lambda, TX power) to provision the Client (Packet) DWDM Pluggable. The pluggable provisioning will be done by the P-PNC. For more details on the optical interface parameters see: [I-D.draft-ietf-ccamp-dwdm-if-param-yang] [I-D.draft-ietf-ccamp-optical-impairment-topology-yang].

In summary the pluggable parameters exchanged from O-PNC to MDSC to P-PNC for end to end service provisioning are:

- Pluggable Service source port-ID
- Pluggable Service destination port-ID
- Central Frequency (Lambda) (common to source and destination)
- TX Output power (source port-ID)
- TX Output power (destination port-ID)
- Operational-mode (compatible)
- Vendor OUI
- Pluggable part number (if the operational mode in not standard)
- Admin-state (common ?)

3. Use Cases

The different services supported by the network are shown in Figure 5. This draft is focused on the inter-domain link, the coherent pluggable interfaces setting through the MC-links setting although the POI first goal is to set an IP service.

```
   +-------------+                                   +-------------+
   |     IP      |                                   |     IP      |
   |             |              IP-link              |             |
   |   <------------------------------------------------------->   |
   |             |                                   |             |
   |             |                                   |             |
   |  +-------+  |              Eth-link             |  +-------+  |
   |  |  <--------------------------------------------------->  |  |
   |  |       |  |                                   |  |       |  |
   |  |       |  |              OTSi-link            |  |       |  |
   |  |  CPI <-------------------------------------------> CPI  |  |
   +--+-------+--+                                   +--+-------+--+
          ^                                                 ^
          |       +-------+                 +-------+       |
          |       |  OLS  |                 |  OLS  |       |
          |       |       |                 |       |       |
          +-----> | <-----------------------------> |<------+
     inter-domain |       |    MC-link      |       | inter-domain
        link      |       |                 |       |    link
                  +-------+                 +-------+
```

IP-link = IP service, out of this document scope
Eth-link = Ethernet connection
CPI = Coherent Pluggable Interface
OTSi-link = Pluggable connection (OTSi connection)
MC-link = Media Channel link (MC optical circuit)

Figure 5: Cross layer interconnection

The use cases supported by the models are:

Inter Layer (or domain) Link discovery and provisioning

The inter-domain links (or inter-domain links) are the interconnections (fiber) between the pluggable ports (in the Packet Layer) and the ROADM ports (in the Optical Layer). They are set in the Packet and DWDM nodes either manually (e.g. CLI) or via PNCs. The values identifying the inter layer links may be defined by MDSC which has the visibility of both IP and Optical layers. The "plug-id" [RFC8795] could be used for this purpose.

Network topology discovery and provisioning

MDSC retrieves the packet network topology from the P-PNC and the optical network topology from the O-PNC. MDSC collects and rebuilds the service topology based on the services information coming from P-PNC and O-PNC as described in [I-D.draft-ietf-teas-actn-poi-applicability]

End to End Packet service provisioning / deletion

MDSC is asked to set a Packet service between two Routers requiring additional connectivity bandwidth.

Optical Circuit provisioning / deletion

MDSC is asked to set an Optical Circuit between two router ports (O-PNC will receive the same request from MDSC). This is specially needed during the network installation to provide Connectivity between two Routers, the IP link will be set up later using this optical tunnel.

LAG extension

MDSC is asked to extend a service bandwidth. This may require more Router optical connectivity.

Optical Restoration

O-PNC detects an optical network failure and reroutes the optical circuits to a different path (and lambda).

Network Maintenance Operations

MDSC is asked to isolate part of the optical network for maintenance and coordinate the O-PNC and P-PNC to preserve the traffic during the maintenance operation.

In the following sub-sections a workflow for each use case is described. Each workflow is analyzed consider a scenario like the one described in option 2. In those cases when the workflow differs between option 1 and option 2, a note describing the differences is added.

3.1. Inter Domain Link discovery and provisioning

The inter-domain links are set in the Packet and DWDM nodes either manually (e.g. via CLI or NMS) during the installation phase when the operator connects the Pluggable Transceiver to the ROADM port via fiber patchcord or is defined by the MDSC controller and provisioned via the PNCs. One method and model to define the Inter Layer Link is, for example, to assign a value to the patchcord (for Tx and RX directions) and store those values in the Pluggable and ROADM port provisioning when the fiber is connected between the two ports. This allows the PNCs to retrieve the values and share them with the MDSC for the correlation and check. Other smarter and automatic methods of patchcord discovery may be defined but are outside of this draft scope.

The inter-domain link must be set (or clear) any time a new pluggable module is installed (or removed) and it is connected to the ROADM port with the fiber patchcord. When a new coherent pluggable interface is installed an inventory notification must be reported to the PNCs and MDSC, the reported info are:

- Pluggable port-ID (e.g. rack/shelf/slot/port or UUID)
- Supported Operational-modes (standard,organizational and explicit)
- Supported Application codes
- Pluggable part number (if the op-mode in not standard)
- Manufacturing data

It would be also possible to auto-discover the inter-domain links between DWDM coherent pluggables and ROADM ports by checking the input/output power levels (and probably switching on/off the lasers of the pluggables). This would require the help of MDSC, O-PNC and P-PNC. The same method could be used to verify the provisioned connectivity. For further study in this draft.

In this use case no difference between option 1 and 2 is foreseen, the MDSC can discover the inter-domain links correlating the information received by the P-PNC and O-PNC.

3.2. Network topology discovery and provisioning

The first operation executed by the P-PNC and O-PNC is to discover the network topology and share it with the MDSC via the MPI. The PNCs will discover and share also the inter-domain links so that the MDSC can rebuild the full network topology associating the DWDM Router ports to the ROADM ports. Once the association is discovered the P-PNC must share the characteristics of Pluggable module with the MDSC and then MDSC with the O-PNC. At this point the Hierarchical controller (MDSC) and the domain controllers have all the information

to commit and honor any service request coming from the OSS/orchestrator. The details of the general operations are described in [I-D.draft-ietf-teas-actn-poi-applicability], while this draft describes how to operate the Pluggable module during the optical circuit set-up operation. As the Pluggable can be inserted or remove at any time it is relevant to have admin and operational state notification from the network to the PNC and MDSC.

Also in this case the MDSC can retrieve all the needed info in collaboration with the P-PNC and O-PNC.

3.3. End to End service provisioning / deletion

The End to End service provisioning is a multilayer provisioning involving both the packet layer and the optical layer. The MDSC plays a key role as it has the full network visibility and can co-ordinate the different domain controllers operations. The service request can be driven by the operator using the MDSC UI or the MDSC receives the service request from the operator OSS/Orchestrator.

The workflow for the creation of an end to end service is composed by the following steps:

Option 1

1. MDSC receives a end to end service request from OSS/Orchestrator
2. MDSC starts computing the different operations to implement the service.
3. First MDSC starts to compute the routing, the bandwidth, the constrains of the packet service.
4. If the Packet network can support the service without additional connections among the Routers
   4.1. then the packet service is commissioned through the P-PNC
   4.2. a notification with all the service info is sent to OSS.
5. If more optical connectivity is needed
   5.1. MDSC notifies the operator about the extra bandwidth need
   5.2. optionally, automatically identifies the spare router ports to be used for the connection extension (e.g. A and Z).
   5.3. The Router ports (pluggable) must be connected to A' and Z' ROADM ports and must be compatible (in terms of optical parameters, etc.).
6. MDSC (autonomously / under operator demand) asks to O-PNC to set an optical circuit between ROADM ports A' and Z' assuming that the information on the pluggable supported parameters (A and Z):
   - Pluggable Service source port-ID
   - Pluggable Service destination port-ID
   - Operational-mode or standard mode (compatible)
   - Vendor OUI (if the operational mode in not standard)

- Pluggable part number (if the op-mode in not standard)
- Admin-state

are already known by the O-PNC

6.2. the bandwidth (e.g. 100G or 400G, etc.)

6.3. the routing constraints (e.g. SRLG XRO, etc)

7. O-PNC, potentially with the help of a planning tool in charge for planning for mixed optical channels (both usual optical transponders and optical pluggable), calculates the optical route, selects the Lambda, verifies the optical feasibility, calculates the pluggable TX power.

   7.1. If all is OK, provisions the optical circuit in ROADM.

   7.2. If anything went wrong the O-PNC rejects the MDSC request.

8. O-PNC updates the MDSC of successful circuit provisioning including the path, the nominal central frequency, the operational mode (or the explicit optical parameters - see draft-ietf-ccamp-optical-impairment-topology-yang for more details), the TX power, SRLG etc.
   The optical circuit at this point is provisioned but not yet operational (no optical power coming from the transceivers yet).

9. The MDSC updates the service DB and forward the pluggable provisioning parameters to P-PNC to complete the optical set-up.

10. MDSC is ready to commission the packet service through P-PNC

    10.1. has the visibility of end to end optical circuit (active)

    10.2. the packet service is commissioned

    10.3. MDSC service DB is updated

11. MDSC notifies the OSS of successful end to end service set-up

12. The service assurance can then start, through the O-PNC for the optical circuit (including Pluggable Alarms and PM), through the P-PNC for the IP/MPLS service.

NOTE: the Optical service may not be feasible due to optical impairments calculation failure. In this case the O-PNC will reject the optical circuit creation request to MDSC. It is up to the operator (through MDSC) to scale down (e.g. propose a 300Gb/s instead of a 400Gb/s service) the request or plan a network upgrade.

Another point to note is the information about the pluggable are directly collected by O-PNC. In reality this info should be known by the O-PNC at network commissioning time when the Inter Domain Link is set or discovered. The pluggable information may have multiple instances when the pluggable support multiple bit rate (e.g. ZR+). In case of multiple bit rate (and multiple operational mode) the O-PNC can decide to propose to MDSC a different bit rate (higher or lower) calculated in base of the optical validation algorithms. That is: MDSC ask for a 400Gb/s bit rate while O-PNC proposer a 300Gb/s bit rate, instead of rejecting the circuit request.

Option 2

1. MDSC receives a end to end service request from OSS/Orchestrator
2. MDSC starts computing the different operations to implement the service.
3. First MDSC starts to compute the routing, the bandwidth, the constrains of the packet service.
4. If the Packet network can support the service without additional connections among the Routers.
   4.1. then the packet service is commissioned through the P-PNC
   4.2. a notification with all the service info is sent to OSS.
5. If more optical connectivity is needed
   5.1. MDSC notifies the operator about the extra bandwidth need
   5.2. optionally, automatically identifies the spare router ports to be used for the connection extension (e.g. A and Z).
   5.3. The Router ports (pluggable) must be connected to A' and Z' ROADM ports and must be compatible (in terms of optical parameters, etc.).
6. MDSC (autonomously / under operator demand) asks to O-PNC to set an optical circuit between ROADM ports A' and Z' providing information on:
   6.1. the pluggable supported parameters (A and Z)
      - Pluggable Service source port-ID
      - Pluggable Service destination port-ID
      - Operational-mode or standard mode (compatible)
      - Vendor OUI (if the operational mode in not standard)
      - Pluggable part number (if the op-mode in not standard)
      - Admin-state (common ?)
   6.2. the bandwidth (e.g. 100G or 400G, etc.)
   6.3. the routing constraints (e.g. SRLG XRO, etc)
7. O-PNC calculates the optical route, selects the nominal central frequency, verifies the optical feasibility, calculates the pluggable TX power.
   7.1. If all is OK, provisions the optical circuit in ROADM.
   7.2. If anything went wrong the O-PNC rejects the MDSC request.
8. O-PNC updates the MDSC of successful circuit provisioning including the path, the nominal central frequency, the operational mode (or the explicit optical parameters - see draft-ietf-ccamp-optical-impairment-topology-yang for more details), the TX power, SRLG, etc. The optical circuit at this point is provisioned but not yet operational (no optical power coming from the transceivers yet).
9. The MDSC updates the service DB and forward the pluggable provisioning parameters to P-PNC to complete the optical set-up.
10. MDSC is ready to commission the packet service through P-PNC
    10.1. has the visibility of end to end optical circuit (active)
    10.2. the packet service is commissioned
    10.3. MDSC service DB is updated

11. MDSC notifies the OSS of successful end to end service set-up
12. The service assurance can then start, through the O-PNC for the optical circuit, through the P-PNC for the pluggable and the IP/MPLS service.

NOTE: the Optical service may not be feasible due to optical impairments calculation failure. In this case the O-PNC will reject the optical circuit creation request to MDSC. It is up to the operator (through MDSC) to scale down (e.g. propose a 300Gb/s instead of a 400Gb/s service) the request or plan a network upgrade. Another point to note is the information sent by MDSC to O-PNC about the pluggable characteristics. In reality this info should be known by the O-PNC at network commissioning time when the Inter Domain Link is set or discovered. The pluggable information may have multiple instances when the pluggable support multiple bit rate (e.g. ZR+). In case of multiple bit rate (and multiple operational mode) the O-PNC can decide to propose to MDSC a different bit rate (higher or lower) calculated in base of the optical validation algorithms. That is: MDSC ask for a 400Gb/s bit rate while O-PNC proposer a 300Gb/s bit rate, instead of rejecting the circuit request.

3.4. Optical Circuit provisioning / deletion

Upon receiving an optical service request from the OSS/Orchestrator, the MDSC starts performing the different operations to implement the optical service (e.g. from A to Z). As an alternative the service request can be driven by the operator using the MDSC UI.

The steps of the workflow are:

1. MDSC receives a end to end service request from the OSS/Orchestr
2. MDSC starts computing the different operations to implement the service.
3. to check whether the optical connectivity is feasible
   3.1. automatically identifies the router ports to be used for the optical connection (e.g. A and Z).
   3.2. The Router ports (pluggable) must be connected to A' and Z' ROADM ports and must be compatible (in terms of optical parameters, etc.).
4. MDSC asks to O-PNC to set the optical circuit between ROADM ports A' and Z' providing information on:
   4.1. the pluggable supported parameters (A and Z)
      - Pluggable Service source port-ID
      - Pluggable Service destination port-ID
      - Operational-mode or standard mode (compatible)
      - Vendor OUI (if the operational mode in not standard)
      - Pluggable part number (if the op-mode in not standard)
      - Admin-state (common ?)
   4.2. the bandwidth (e.g. 100G or 400G, etc.)
   4.3. the routing constraints (e.g. SRLG XRO, etc)
5. O-PNC calculates the optical route, selects the Lambda, verifies the optical feasibility, the pluggable TX power.
   5.1. If all is OK, provisions the optical circuit
6. O-PNC updates the MDSC of successful circuit provisioning including the path, the Lambda, the operational mode (or the explicit optical parameters), the TX power, etc.
7. The MDSC updates the service DB and forward the pluggable provisioning parameters to P-PNC to complete the optical set-up
8. MDSC verifies the end to end optical circuits (active)
9. The MDSC notifies the OSS of successful optical circuit set-up.
10. The assurance operational can start, fully driven by O-PNC in option 1 or coordinated by MDSC in option 2.

NOTE: the Optical service may not be feasible due to optical impairments calculation failure. In this case the O-PNC will reject the optical circuit creation request to MDSC. It is up to the operator (through MDSC) to scale down the request or plan a network upgrade.

The same consideration done in the previus use case are applicable here.

3.5. LAG extension

Upon receiving a LAG service request from OSS/Orchestrator, the MDSC start computing the different operations to implement the request.

The MDSC would determine if an existing multi-layer connection exists between the routers participating in the LAG. If so, the MDSC would request the P-PNC to configure and add the new LAG bundle member link

using this existing connection, and notify the OSS confirmation of the additional link. If more optical connectivity is needed, then the procedures defined in Section 3.3 would be followed.

3.6. Optical Restoration

For this use case the trigger for the Domain controller and MDSC to take actions is coming from the optical data plane when the O-PNC detects or is notified about an optical network failure (e.g. a fiber cut or a node failure). This kind of events affect the traffic and a number of optical circuits are lost.

1. First action is taken by the O-PNC to identify what are the affected circuits enabled to restoration
2. For the circuits enabled to restoration O-PNC starts to compute
   2.1. the restore paths
   2.2. their feasibility and any optical parameter change (e.g. lambda retuning, TX power, etc.)
3. If the restore path and all parameters are OK for the optical feasibility
   3.1. the restore path is provisioned
   3.2. nodifications to MDSC are sent to notify the circuits data
      - circuit path + SRLG
      - Pluggable Service source port-ID
      - Pluggable Service destination port-ID
      - Operational-mode or standard mode (compatible)
      - Admin-state (common ?)
4. The MDSC updates the circuit DB and forward any pluggable provisioning change to P-PNC
5. P-PNC will take care to apply the new provisioning data to the pluggables (e.g. lambda, operational data, TX power, etc.)
6. The Restoration process is then completed and the IP connection between the routers is recovered.

NOTE: the restoration may not be feasible due to optical impairments calculation failure. In this case the O-PNC will notify the optical circuit restoration failure to MDSC. It is up to the operator, through MDSC, to take actions and/or plan a network upgrade.

In case the optical circuit restoration is revertible, is again O-PNC responsibility to monitor the failure after the fix and start the revert procedure to bring the restore path to the original route.

3.7. Network Maintenance Operations

The maintenance operation is requested by the OSS when a part of the network needs a maintenance activity. There could be Packet network maintenance or Optical network Maintenance. As an alternative the maintenance request can be driven by the operator using the MDSC UI.

The Packet network maintenance is simple and is addressed by the MDSC in cooperation with the P-PNC.

The optical network maintenance is more complex and needs the MDSC coordination to ask the P-PNC to move away the traffic from the resources under maintenance in the optical network. That means MDSC has to search in the service DB whether a service is using a definite optical link and re-route the service to a part of the optical network not affected by the maintenance operation. Upon maintenance completion the MDSC will bring all the traffic back to the original route.

4. Optical Interface for external transponder in a WDM network

This document proposes an augmentation to the ietf-interface module called ietf-ext-xponder-wdm-if. The ietf-ext-xponder-wdm-if, author note: define the model, is an augment to the ietf-interface. It allows the user to set the operating mode of transceivers as well as other operational parameters. The module also provides threshold settings and notifications to supervise measured parameters and notify the client.

5. Structure of the Yang Module

ietf-ext-xponder-wdm-if is a top-level model for the support of this feature.

Editor's note: This chapter is to be completed.

6. Security Considerations

This document does not introduce any new interfaces or protocols in addition to the ACTN architecture defined in [RFC8453], hence the same considerations apply. In addition, IPsec and HMAC- MD5 authentication are common examples of existing mechanisms.

7. IANA Considerations

This document registers a URI in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registration is requested to be made:

URI: urn:ietf:params:xml:ns:yang:ietf-interfaces:ietf-ext-xponder-wdm-if

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [RFC6020].

This document registers a YANG module in the YANG Module Names registry [RFC6020].

prefix: [I-D.draft-ietf-ccamp-dwdm-if-param-yang]

8. References

8.1. Normative References

[I-D.draft-ietf-ccamp-dwdm-if-param-yang]
Galimberti, G., Hiremagalur, D., Grammel, G., Manzotti, R., and D. Breuer, "A YANG model to manage the optical interface parameters for an external transponder in a WDM network", Work in Progress, Internet-Draft, draft-ietf-ccamp-dwdm-if-param-yang-10, 23 October 2023, <https://datatracker.ietf.org/doc/html/draft-ietf-ccamp-dwdm-if-param-yang-10>.

[I-D.draft-ietf-ccamp-optical-impairment-topology-yang]
Beller, D., Le Rouzic, E., Belotti, S., Galimberti, G., and I. Busi, "A YANG Data Model for Optical Impairment-aware Topology", Work in Progress, Internet-Draft, draft-ietf-ccamp-optical-impairment-topology-yang-14, 23 October 2023, <https://datatracker.ietf.org/doc/html/draft-ietf-ccamp-optical-impairment-topology-yang-14>.

[I-D.draft-ietf-teas-actn-poi-applicability]
Peruzzini, F., Bouquier, J., Busi, I., King, D., and D. Ceccarelli, "Applicability of Abstraction and Control of Traffic Engineered Networks (ACTN) to Packet Optical Integration (POI)", Work in Progress, Internet-Draft, draft-ietf-teas-actn-poi-applicability-10, 19 January 2024, <https://datatracker.ietf.org/doc/html/draft-ietf-teas-actn-poi-applicability-10>.

[ITU.G694.1]
International Telecommunications Union, "Spectral grids for WDM applications: DWDM frequency grid", ITU-T Recommendation G.698.2 , February 2012.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2 , November 2009.

[ITU.G872] International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872 , January 2017.

[OIF-400ZR-01-0]
Optical Internetworking Forum (OIF), "Implementation Agreement 400ZR", OIF OIF-400ZR-01-0 , March 2020.

[Open_ZR-Plus_MSA]
OpenZR+ Multi-Source Agreement, "400ZR+ Multi-Source Agreement", OpenZR+ Open ZR+ MSA , September 2020.

[RFC1930] Hawkinson, J. and T. Bates, "Guidelines for creation, selection, and registration of an Autonomous System (AS)", BCP 6, RFC 1930, DOI 10.17487/RFC1930, March 1996, <https://www.rfc-editor.org/rfc/rfc1930>.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <https://www.rfc-editor.org/rfc/rfc3688>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <https://www.rfc-editor.org/rfc/rfc6020>.

[RFC8453] Ceccarelli, D., Ed. and Y. Lee, Ed., "Framework for Abstraction and Control of TE Networks (ACTN)", RFC 8453, DOI 10.17487/RFC8453, August 2018, <https://www.rfc-editor.org/rfc/rfc8453>.

[RFC8795] Liu, X., Bryskin, I., Beeram, V., Saad, T., Shah, H., and O. Gonzalez de Dios, "YANG Data Model for Traffic Engineering (TE) Topologies", RFC 8795, DOI 10.17487/RFC8795, August 2020, <https://www.rfc-editor.org/rfc/rfc8795>.

8.2. Informative References

[MANTRA-whitepaper-IPoWDM]
"MANTRA whitepaper IPoWDM convergent SDN architecture", August 2022, <https://cdn.brandfolder.io/D8DI15S7/at/n85t9h48bqtkhm9k7tqbs9fv/TIP_OOPT_MANTRA_IP_over_DWDM_Whitepaper_-_Final_Version3.pdf>.

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